以乳房攝影照相模式參考指標評估乳房攝影輻射劑量之安全性

RADIATION DOSE SAFETY IN MAMMOGRAPHY BY EVALUATION OF EXPOSURE PARAMETER SETTINGS

楊繼盛[1] 徐建業[1] 邱泓文[1] 陳立銘[1] 廖月美[2] 魯承章[2]
Chi-Sheng Yang[1] Chien-Yeh Hsu[1] Hung-Wen Chiu[1]
Li-Ming Chen[1] Yue-Mei Liao[2] Cheng-Zhang Lu[2]
[1]台北醫學大學醫學資訊所 [2]台北市立萬芳醫院放射科
[1] Graduate Institute of Medical Informatics, Taipei Medical University, Taipei, Taiwan
[2] Radiology Department, Taipei Municipal WanFang Hospital, Taipei, Taiwan

一、中文摘要

美國於 1992 年訂定乳房攝影品管標準法案(MQSA: Mammography Quality Standard Act)，該項法案中規定每張乳房攝影片之平均乳腺劑量之最大值以不超過 300 毫雷德為標準[7]。乳房攝影品質管制逐漸為放射診斷領域所重視且不可忽略的項目之一。

本研究於台北某市立醫院臨床測試下， 320 位受試者每位執行 4 組乳房攝影照相，平均受測年齡為 51.3 歲。結果顯示正位向與斜位向之乳房壓迫厚度具有顯著差異(p<0.001)。放射師所選定之照相 kV 與受檢者之乳房厚度於標準四組 X 光照射角度具有高度之正相關性(p<0.001)。

於乳房攝影照相模式參考指標下接受估計的 1280 組乳房攝影片中， 87%乳房攝影片使用 Mode 1 與 Mode 2 照相模式參考指標，其所接受之輻射劑量遠低於 300 毫雷德(Mode 1: Mean=118.4±60.2 毫雷德 with 571 D.F., p<0.001; Mode 2: Mean=200.8±85.4 毫雷德 with 537 D.F., p<0.001）。受試者於 Mode 3 下約有 5%高於最大輻射吸收劑量 300 毫雷德(Mean=314.4±140.6 毫雷德 with 147 D.F., p=0.292) 。

照相模式參考指標下 Mode 1 之乳房壓迫厚度設定為 0 至 30 毫米；Mode 2 之乳房壓迫厚度設定為 31 至 45 毫米;Mode 3 之乳房壓迫厚度設定為 46 至 60 毫米。結果顯示受檢者於照相模式參考指標下所接收之輻射吸收劑量符合法案 MQSA 中所訂定之標準。

以本次估計結果顯示平均乳房壓迫厚度為 32.3 毫米(p<0.001)，我們建議針對乳房壓迫厚度低於 45 毫米以下者，其所接受之平均乳腺劑量以不高於 200 毫雷德為參考指標。最後評估受試者之年齡於接受乳房攝影所接受之輻射吸收劑量亦無顯著差異(p<0.001)。

Abstract

Mammography Quality Standard Act (MQSA) was enacted in United States since 1992, and Mammography Quality Standard Reauthorized Act (MQSRA) also has been enacted in 1998. The maximum limitation of Average Glandular Dose (AGD) is 300mrad (3mGy) per film [7].

320 subjects are participant in our study, every subject takes 4 exposure views(mammograms). Average estimated age is 51.3 years old. There is a significant difference between CC and MLO breast thickness (p<0.001). Technologists selected proper exposure parameter settings.

The results show 87% mammograms have significantly lower absorbed radiation dose compared with 300mrad when breast compressed thickness below 45mm(Mode 1: Mean=118.4±60.2mrad with 571 D.F., p<0.001; Mode 2: Mean=200.8±85.4mrad with 537 D.F., p<0.001). About 5% estimated mammograms result in higher absorbed radiation dose (>300mrad) when breast thickness between 46mm to 60mm (Mode 3: Mean=314.4±140.6mrad with 147 D.F., p=0.292). We recommend AGD reference shouldn't exceed 200mrad when Breast compressed thickness smaller than 45mm, On the other hand, we estimated relationship between patient age and absorbed radiation dose. There is no significant between age and absorbed radiation dose (p<0.001).

Keywords: Average glandular dose, AGD, HVL, Breast compressed thickness, Exposure Parameter Setting

二、Background

Since 2002, Bureau of Health Promotion (BHP), Department of Health starts breast screening clinical trail in Taiwan [1]. There were 54 hospitals joined this project in 2002, 78 hospitals joined in 2003, and it will be 108 hospitals joined this clinical trail in 2004(see *Figure1*).

Department of Health, Executive Yuan, Taiwan also announced that government insurance starts screening mammogram on July, 2004. Woman who more than 50 years old can get mammogram cost-free every one to two years.

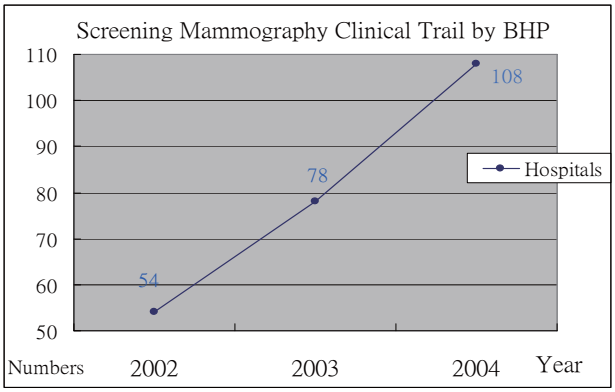

Figure 1 Screening Mammography Clinical Trail joined hospital numbers in Taiwan

The average glandular dose is one of the estimated procedures of clinical trails. Nevertheless, the techniques of positioning and exposure parameter settings are very important in mammogram. Wrong positioning of breast and poor image quality of mammogram are the major features of retake mammogram behaviors. And these behaviors are the major point of increasing unnecessary patient radiation dose.

In United States, radiologists and technicians need to get lots of training courses and certifications. And also mammographic units must be under certain quality control procedures [6]. All these above are based on government act named Mammography Quality Standard Act (MQSA) since 1992 [7]. The final corrected rules named Mammography Quality Standard Reauthorized Act (MQSRA) have been published in 1998[7]. All facilities have been followed final corrected rules since 28, Oct. 2002.

In Taiwan, The Radiology Society Republic of China (RSROC) and Association of Radiology Technologist of ROC (ARTROC) also start mammography course training for radiologists and technologists. Of course Both RSROC and ARTROC follow accredited rules.

The way of select X-ray parameter settings including target, filter, kV, and Automatic Exposure Control (AEC) is done by specialist heuristic and experience. The glandular tissue is the most sensitive tissue in related to x-ray penetration and also the major tissue of considering breast cancer [2].

Measuring methods such as radiation beam quality(i.e. Half Value Layer (HVL) value), entrance radiation dose, and calculating the AGD are followed American College Radiology(ACR) standard and the FDA published law [5][8].

This evaluation records the X-ray tube target material, filter setting, kV, mAs, compression thickness, and volunteer's age to estimate the radiation dose. Not only the unique of breast tissue but also the whole procedure is highly sensitive if one of them is not within quality criterion.

三、Material and Method

We Selected Siemens Mammomat 3000 Mammographic unit and ACR approved Phantom (type RMI-156) to estimate AGD references [6]. The standard phantom is composed with 50% adipose and 50% glandular tissue.

Estimating X-ray Beam Quality (HVL)

There are three x-ray exposure parameter setting modes in the followings: **Mode 1**: Choose Molybdenum/Molybdenum (Mo/Mo) X-ray tube Target/Filter material, select 25kVp and Automatic Exposure Control (AEC) mode [3]. **Mode 2**: Choose Mo/Mo combination, select 26kVp and AEC mode. **Mode 3**: Choose Molybdenum/Rhodium (Mo/Rh) X-ray tube combination, select 27kVp and AEC mode.

We used 99.9% pure aluminum filters, ionization chamber and electrometer to measure the x-ray beam quality base on ACR procedure [6]. All 3 mode HVL values are measured.

Establishing AGD Reference

We used RMI-156 phantom to estimate entrance radiation dose. Then we calculated AGD via entrance dose and HVL value. Three AGD reference modes are established through this procedure.

The AGD equation shows as following:

AGD=DgN * XESE

Where DgN is Glandular dose (in mrad) for 1 Roentgen(R) entrance exposure conversion factor, XESE is entrance dose on the surface of phantom [8].

Mammogram Exposure Data Evaluation

Total 1280 mammograms were examined in our study, we recorded patient ID, age, and compressed breast thickness. And we collected every X-ray exposed parameters including kV, mAs, target, and filter.

Because of the mAs value is proportional to radiation dose[4], we can use mAs value to simulate the patient radiation dose.

T-test and correlation coefficient are our

major statistical terms in the study.

四、Result

AGD Reference in 3 modes

The technologists established 3 modes HVL values (see *Table 1*) .Too low HVL value shows the worse efficiency of photon energy which is produced. On the other hand, too high HVL value shows the hard (Strong) photons; it reduced the latitude (dynamic) of breast tissue and got the poor image quality result.

Table 1 HVL Value in mm Aluminum

Nominal kVp setting	25	26	27
Target material	Mo	Mo	Mo
Filter	Mo	Mo	Rh
mAs	56	50	56
Calculated HVL (mm Al)	0.334	0.350	0.438
Minimum allowed HVL	0.28	0.29	0.3
Maximum allowed HVL	0.37	0.38	0.46

The maximum limitation of AGD is 300 mrad, we obtained 198.2 mrad, 185.9 mrad, and 124.7 mrad individually (see *Table 2*). That means the mammographic unit is fulfilled the AGD criteria.

Table 2 Calculated AGD Value in 3 Different Modes

Mode	1	2	3
Nominal kVp setting	25	26	27
Target /Filter	Mo/Mo	Mo/Mo	Mo/Rh
mAs	141.3	112	65.1
Entrance Dose(mGy)	10.13	9.23	5.2
Calculated AGD(mrad)	198.2	185.9	124.7

Breast Compressed Thickness Analysis

The breast compressed thickness is the most important feature in exposure parameter settings. The average compressed breast thickness (n=1280) in four views are showing in the following (see *Table 3*): RCC=33.8mm, RMLO=31.0mm, LCC=33.5mm, LMOL=31.0mm.

The breast compressed thickness on left side CC view and left side MLO view are significant different (t =8.658 with 319 D.F., p<0.001).

Table 3 Breast Compressed Thicknesses in 4 Views

Field	Mean	S.D.	Min	Max
RCC	33.8	12.04	3	80
RMLO	31.0	11.43	3	66
LCC	33.5	11.77	3	73
LMLO	31.0	10.84	5	64

The breast compressed thickness on right side CC view and right side MLO view are also significant different (t = 8.158 with 319 D.F., p<0.001). We conclude that breast compressed thickness on CC view and MLO view are significantly different.

kVp setting estimation

To evaluated the relationship between kVp and breast compressed thickness, we obtained significant positive correlation coefficient(p<0.001) (see *Table 4*), so we can state that all four views of kVp are proper settings by technologists.

Table 4 Correlation Regression Results in kVp and Compressed Breast Thickness.

Project View	R- Square	T-Value
RCC	0.8242	38.61 (p<0 .001)
LCC	0.8152	37.45 (p <0 .001)
RMLO	0.7301	29.33 (p <0 .001)
LMLO	0.7692	32.56 (p<0.001)

Radiation Dose Safety evaluation

On mode 1 and mode 2, we got lower X-ray absorbed radiation dose through subjects estimations The results show 87% cases have significantly lower X-ray absorbed radiation dose when breast compressed thickness below 45mm(Mode 1(0 to 30mm): t= -72.99 with 571 D.F., p<0.001; Mode 2(31 to 45mm): t= -26.94 with 537 D.F., p<0.001）. On mode 3, About 5% estimated mammograms result in highly X-ray absorbed radiation dose when breast compressed thickness between 46mm to 60mm (Mode 3: t= 1.06 with 147 D.F., p=0.292).

五、Conclusion

One of Our hypothesis is that younger women who will get the higher radiation dose. On the regression of age and mAs values, we got partial

positive relationship (r-square between 0.0606~0.0899, $p<0.001$) on 4 views, the result shows no significant between age and radiation dose. It means younger woman who takes mammogram wouldn't cause higher radiation dose. But in the scatter plot, it shows a positively skewed distribution trend that the less of the age the higher of the mAs value. (see *Figure 2*).

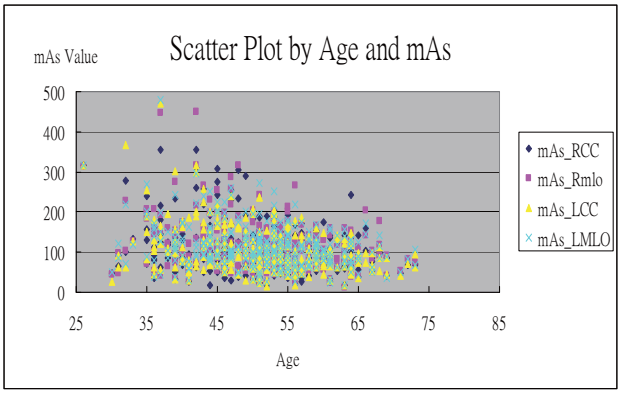

Figure 2 Scatter Plot by Age and mAs Value

Due to **"As Low As Reasonably Achievable" (ALARA)** X-ray radiation protection philosophy, we recommend to establish a lower AGD maximum limitation for patient with thinner breast. When Breast compressed thickness smaller than 45mm, the AGD reference shouldn't exceed 200mrad for the purpose of patient safety.

六、Reference

[1] 李三綱,許居誠,黃怡璇,楊繼盛 (2004) 乳房X 光攝影品質認證制度之臨床試辦計畫;行政院衛生署.

[2] Aichinger H., Dierker J., Saabel M., et al. (1994) *Image Quality and dose in Mammography*. Electromedica 62 no.2:7-11.

[3] Anne C., Per H. R., et al (1997) *Influence of Anode-Filter Combinations in Image Quality and Radiation Dose.* Radiology vol. 203, No.2.

[4] Bushong Stewart C.(1997) *Radiology Science for Technologists*. P131-137.

[5] Dance DR (1990) *Monte Carlo calculation of conversion factors for the estimation of mean glandular breast dose*. Phy.Med.Biol. 35:1211-1219.

[6] Hendrick R. Edward, Bassett Lawrence, Botsco Margaret A., et al (1999) *Mammography Quality Control Manua*l. American College of Radiology.

[7] Mammography Quality Standard Act (MQSA) (1992). FDA; (Public Law 102-539), Mammography Quality Standard Reauthorization Act of 1998 (MQSRA) (Public Law 105-248).

[8] Wu X , Gingold E, Barnes G et al (1994) *Normalized Average Glandular Dose in Molybdenum Target – Rhodium Filter and Rhodium Target – Rhodium Filter Mammography*. Radiology 193:83-89.